ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
UNITED STATES ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

April 18, 1973

Honorable Dixy Lee Ray
Chairman
U. S. Atomic Energy Commission
Washington, D. C. 20545

Subject: REPORT ON TURBINE MISSILES

Dear Dr. Ray:

The ACRS report of December 18, 1972, Status of Generic Items Relating to Light-Water Reactors, included the subject of Turbine Missiles as Item 5 of Group II (Resolution Pending). This topic has been a frequent matter of discussion during Committee review of applications, and was specifically mentioned in reports on Point Beach Units 1 and 2, April 16, 1970; H. B. Robinson Unit 2, April 16, 1970; Millstone Unit 2, May 15, 1970; Shearon Harris Units 1, 2, 3 and 4, January 17, 1973; Waterford Steam Electric Station, Unit 3, January 17, 1973; and North Anna, Units 3 and 4, March 13, 1973.

Historically, there have been several instances of turbine failure, with ejection of large fragments as high energy missiles. Reactor subsystems are normally housed in substantial reinforced concrete structures. For a turbine failure to cause serious release of radioactivity, it would be necessary for a missile to penetrate a structure and to strike a particular target or combination of targets in a manner that would negate safe shutdown capability or that would breach containment coincident with a release of radioactivity.

Key elements in determining the overall probability of serious release of radioactivity are the probabilities of turbine failure at design speed and at runaway speed, spatial distribution of missiles with due allowance for possible deflection, the size and location of vulnerable targets, and the penetration resistance of structures. These probabilities have been estimated by manufacturers of large turbines and by others, and the topic has also been addressed in varying detail by applicants. A comprehensive review of this topic by Dr. Bush is referenced at the end of this report.

Applicants generally conclude that the combined probability of turbine failure, missile strike, and penetration of a critical structure is negligible. The Committee believes that more information is needed and that a Regulatory Guide should be prepared on the subject of turbine missiles. The Committee makes the following observations and recommendations.

1) Mechanical-hydraulic systems have been generally used for overspeed protection, and more recently electro-hydraulic systems have been used. Applicants consider both these systems to be highly reliable, but, in view of the possible consequences of overspeed, the Committee believes that applications to be received in the future should describe the turbine overspeed control system in sufficient detail to permit the Regulatory Staff to evaluate the degree of independence and redundancy of components of the overspeed trip system. This information may be provided by adequate manufacturers' reports.

2) For applications to be received in the future, if the turbine orientation is relatively unfavorable with respect to vulnerability of the plant to missiles (e.g., the plane of the rotating disk intersects the containment), a justification of the selected orientation should be provided.

3) Calculations of the penetration of concrete by missiles are generally based on empirical formulas for penetration, perforation, and spalling derived from tests with military projectiles. The penetration calculated by different formulas may vary by a factor of two or more in the velocity range of interest. It is also evident that the formulas should be modified when applied to irregularly shaped turbine missiles impinging on a heavily reinforced wall such as that of a reactor containment building. The Committee recommends that a critical review be made of the applicability of available formulas and that consideration be given to conducting a test program for determining the formula parameters applicable to turbine fragment profiles, impinging at various velocities on appropriate reinforced concrete specimens, and possibly at various angles of incidence.